US006075875A

United States Patent [19]

Gu

[11] Patent Number: 6,075,875

[45] Date of Patent: *Jun. 13, 2000

[54] **SEGMENTATION OF IMAGE FEATURES USING HIERARCHICAL ANALYSIS OF MULTI-VALUED IMAGE DATA AND WEIGHTED AVERAGING OF SEGMENTATION RESULTS**

[75] Inventor: **Chuang Gu**, Redmond, Wash.

[73] Assignee: **Microsoft Corporation**, Redmond, Wash.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/722,981**

[22] Filed: **Sep. 30, 1996**

[51] **Int. Cl.**[7] **G06K 9/00**

[52] **U.S. Cl.** **382/107**; 382/173

[58] **Field of Search** 382/103, 107, 382/173, 260; 348/699

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,873,972	3/1975	Levine	340/146.3 AC
4,630,306	12/1986	West et al.	382/21
4,745,633	5/1988	Waksman et al.	382/56
4,751,742	6/1988	Meeker	382/41
4,754,492	6/1988	Malvar	382/41
4,783,833	11/1988	Kawabata et al.	382/22
4,802,005	1/1989	Kondo	358/135
4,833,721	5/1989	Okutomi et al.	382/21
4,905,295	2/1990	Sato	382/21
4,912,549	3/1990	Altman et al.	358/17
4,961,231	10/1990	Nakayama et al.	382/21
4,999,705	3/1991	Puri	358/136
5,020,121	5/1991	Rosenberg	382/56
5,031,225	7/1991	Tachikawa et al.	382/21
5,034,986	7/1991	Karmann et al.	382/1
5,067,014	11/1991	Bergen et al.	358/105

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

0 395 293	10/1990	European Pat. Off.	H04N 7/137
0 474 307	3/1992	European Pat. Off.	G06F 15/70
0 497 586	8/1992	European Pat. Off.	G06F 15/70
0614 318	9/1994	European Pat. Off.	H04N 7/13
0 625 853	11/1994	European Pat. Off.	H04N 7/13
WO 91/11782	8/1991	WIPO	G06K 9/36

OTHER PUBLICATIONS

Sanson, *Motion Affine Models Identification and Application to Television Image Coding*, SPIE vol. 1605 Visual Communications and Image Processing '91: Visual Communication, pp. 570–581.

Hötter, *Optimization and Efficiency of an Object–Oriented Analysis–Synthesis Coder*, IEEE Transactions on Circuits and Systems for Video Technology, Apr. 1994, No. 2, pp. 181–194.

Zakhor et al, *Edge–Based 3–D Camera Motion Estimation with Application to Video Coding*, IEEE Transactions on Image Processing, Oct. 1993, No. 4, pp. 481–498.

(List continued on next page.)

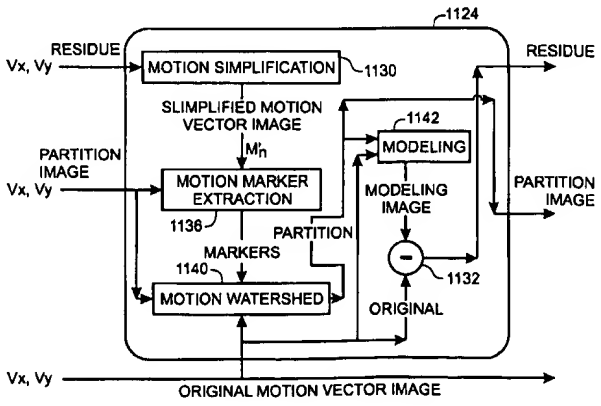
Primary Examiner—Andrew W. Johns

Attorney, Agent, or Firm—Klarquist Sparkman Campbell Leigh & Whinston, LLP

[57] **ABSTRACT**

Homogeneous moving objects of arbitrary shapes are segmented and tracked with respect to the motion of the objects. In an intraframe mode of operation, a segmentation method includes obtaining a motion representation of corresponding pixels in the selected video image frame and a preceding video image frame to form motion-segmented video image features. Video image features are also segmented according to their spatial image characteristics (e.g., color) to form spatially-segmented video image features. Finally, the video image features are jointly segmented as a weighted combination of the motion-segmented video image features and the spatially-segmented video image features. The joint motion and spatial segmentation of image features provides enhanced accuracy in representing moving image features. This enhanced accuracy is particularly beneficial because the motion of image features is a significant display characteristic for human observers.

51 Claims, 40 Drawing Sheets



U.S. PATENT DOCUMENTS

5,070,465	12/1991	Kato et al.	395/141
5,073,955	12/1991	Evers	382/21
5,086,477	2/1992	Yu et al.	382/8
5,103,305	4/1992	Watanabe	358/105
5,103,306	4/1992	Weiman et al.	358/133
5,117,287	5/1992	Koike et al.	358/133
5,148,497	9/1992	Pentland et al.	382/54
5,155,594	10/1992	Bernstein et al.	358/136
5,214,504	5/1993	Toriu et al.	358/105
5,251,030	10/1993	Tanaka	358/136
5,258,836	11/1993	Murata	358/136
5,259,040	11/1993	Hanna	382/41
5,294,979	3/1994	Patel et al.	348/624
5,295,201	3/1994	Yokohama	382/48
5,329,311	7/1994	Ward et al.	348/180
5,376,971	12/1994	Kadono et al.	348/699
5,424,783	6/1995	Wong	348/606
5,459,519	10/1995	Scalise et al.	348/431
5,467,442	11/1995	Tsubota et al.	395/135
5,477,272	12/1995	Zhang et al.	348/407
5,517,327	5/1996	Nakatani et al.	358/462
5,557,684	9/1996	Wang et al.	382/107
5,572,258	11/1996	Yokoyama	348/415
5,574,572	11/1996	Malinowski et al.	358/451
5,594,504	1/1997	Ebrahimi	348/416
5,598,215	1/1997	Watanabe	348/416
5,621,660	4/1997	Chadda et al.	364/514 R
5,642,166	6/1997	Shin et al.	348/416
5,731,849	3/1998	Kondo et al.	348/699
5,734,737	3/1998	Chang et al.	382/107

OTHER PUBLICATIONS

Meyer et al., *Region–Based Tracking Using Affine Motion Models in Long Image Sequences*, CVGIP: Image Understanding, vol. 60, No. 2, Sep. 1994, pp. 119–140.

Ozer, *Why MPEG is Hot*, PC Magazine, Apr. 11, 1995, pp. 130–131.

Fogg, *Survey of Software and Hardware VLC Architecture*, SPIE vol. 2186, pp. 29–37.

Video Coding for Low Bitrate Communication, Draft Recommendation H.263, International Telecommunication Union, Dec. 1995, 51 pages.

Foley et al. *Computer Graphics Principles and Practice*, Addison–Wesley Publishing Company, Inc., 1990, pp. 835–851.

Nieweglowski et al., *A Novel Video Coding Scheme Based on Temporal Prediction Using Digital Image Warping*, IEEE Transactions on Consumer Electronics, vol. 39, No. 3, Aug. 1993, pp. 141–150.

Orchard, *Predictive Motion–Field Segmentation for Image Sequence Coding*, IEEE Transactions on Circuits and Systems for Video Technology, vol. 3, No. 1, Feb. 1993, pp. 54–70.

Seferidis et al. *General Approach to Block–Matching Motion Estimation*, Optical Engineering, vol. 32, No. 7, Jul. 1993, pp. 1464–1474.

Chang et al., *Transform Coding of Arbitrarily–Shaped Image Segments*, Proceedings of the ACM Multimedia 93, Aug. 1, 1993, pp. 83–90.

Chen et al.,*A Block Transform Coder for Arbitrarily Shaped Image Segments*, ICIP–94, vol. 1/III, Nov. 13, 1994, pp. 85–89.

Franke et al., *Constrained Iterative Restoration Techniques: A Powerful Tool in Region Oriented Texture Coding*, Signal Processing IV: Theories and Applications, Sep. 1988, pp. 1145–1148.

Pennebaker et al., *JPEG Still Image Data Compression Standard*, Chapter 20, pp. 325–349, 1993.et al.

Wong, *Nonlinear Scale–Space Filtering and Multiresolution System*, 1995 IEEE, pp. 774–787.

Defée et al., *Nonlinear Filters in Image Pyramid Generation*, 1991 IEEE, pp. 269–272.

Ranka et al, *Efficient Serial and Parallel Algorithms for Median Filtering*, 1991 IEEE, pp. 1462–1466.

Haddad et al, *Digital Signal Processing, Theory, Applications, and Hardware*, 1991, pp. 257–261.

PCT/US96/15892 search report dated Feb. 17, 1997.

PCT/US96/15892 search report dated Apr. 28, 1997.

PCT/US97/04662 search report dated Jun. 9, 1997.